Autonomous Water Quality Monitoring System

Arelys Navarro (EE) Daniel Mendoza (CPE) Jazmin Villegas (EE)
Professor G. P. Li
Department of Electrical Engineering and Computer Science
The Henry Samueli School of Engineering
University of California · Irvine

Background

Water quality monitoring is important for many applications such as ensuring freshwater is safe for drinking, for scientific research, and for monitoring general changes in the properties of water.

Examples:

- The United States Geological Survey (USGS) regularly monitors 7,200 lakes and reservoirs
- Public beaches are tested daily for E. coli outbreaks,

Today, water samples are mainly acquired manually:

- Time- consuming
- Expensive
- Often unsafe

Purpose

The goal of this project is to develop and demonstrate a water vehicle with the capability to be directed across a body of water and communicate wirelessly with a ground base.

Our raft will allow volunteers to control the raft and sample water with remote control. This improves:

- Access to large areas and hard-to-reach locations
- On-demand samples
- Sample size and frequency of sampling

Approach

The design of the project was based on engineering an autonomous vehicle. Parameters were determined for the full scale and prototype raft.

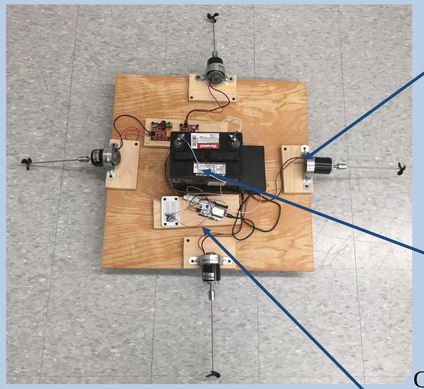
Full-Scale Parameters

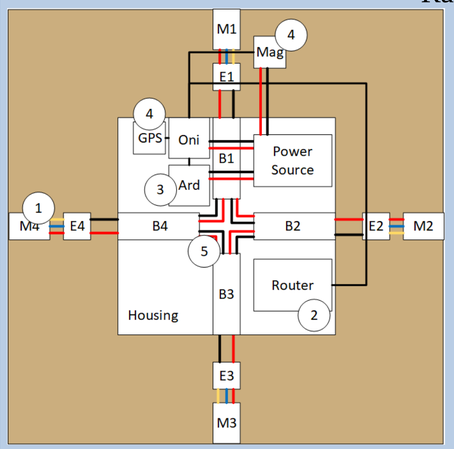
- Payload: 210 lb
- Size: 12-25 square ft
- Speed: > 4.6mph
- Range: 4 miles

Prototype Parameters

Linear scale of 2.45, square scale of 6, cubic scale of 14.7

- Payload: 14.29 lb
- Size: 4 square ft
- Speed: > 1.88mph
- Range: 1.63mile





Numbers in the diagram correspond to the 5 subsystems.

Propulsion System Test

Measuring RPM and duty cycle of motors driven by 1kHz PWM. A hall sensor and magnet were used to track rotations.

Duty Cycle (%)	Frequency (Hz)	RPM
0.00%	0	0
10.98%	13.903	834.18
21.96%	33.174	1990.44
32.94%	43.679	2620.74
43.92%	49.573	2974.38
54.90%	52.62	3157.2
65.88%	54.99	3299.4
76.86%	56.267	3376.02
87.84%	57.352	3441.12
100.00%	59.164	3549.84

(1) Propulsion System

- 4 - 12V/30W/3000RPM DC motors
- Attached propellers

(2) Wireless Telemetry System

- Real-time monitoring and control
- Data transmission.

(3) Motor Control System

- Individual control of motors and LED using PWM Arduino outputs
- Designed for wireless telemetry compatibility

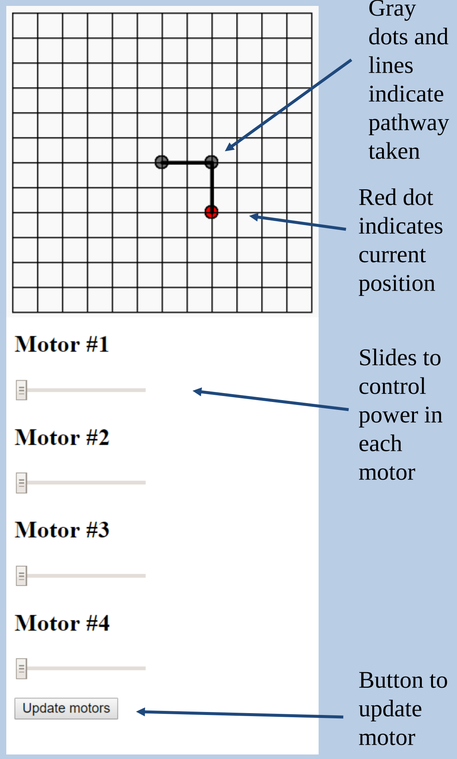
(4) Navigation System

- Retrieves location and orientation through GPS and Magnetometer.

(5) Power System

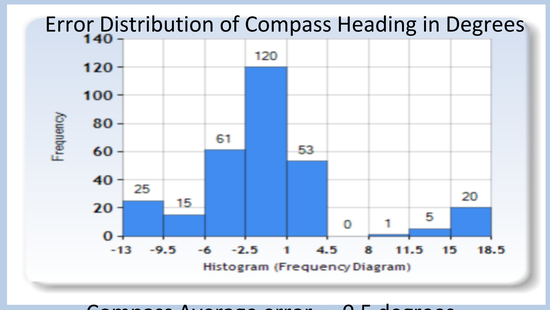
- Supplies power for two different systems through 12V DC battery and 12V power bank.

User Interface

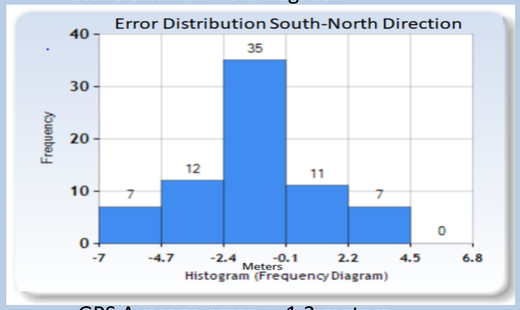


Experiments with Navigation

Conducted experiments to get practical data on sensors readings and analyze trends in the error distribution.



Compass Average error = -0.5 degrees
Std. Deviation = 6.3 degrees



GPS Average error = -1.3 meters
Std. Deviation = 2.45 meters

Future Work

We would like to create a correctional algorithm to create a path and guide the raft along its course. This improvement would also include more options for the user using the interface.

References
[1] Erwin, Martha L, and Pixie A Hamilton. “Monitoring Our Rivers and Streams.” Mercury Contamination from Historical Gold Mining in California, U.S. Geological Survey
[2] Rodriguez, Dylan, and Adrienne Hall-Phillips. Designing, Building, and Managing an Autonomous Boat and Its Transatlantic Crossing Attempt. Worcester Polytechnic Institute, 2014, pp. 9–20, Designing, Building, and Managing an Autonomous Boat and Its Transatlantic Crossing Attempt.
[3] “EarthEcho Water Challenge.” EarthEcho Water Challenge, EarthEcho International.
[4] “Benefits of Automated Composite Samplers.” San Jose/ Santa Clara Water Pollution Control Plant, 2008.
[5] “ESM30 Autonomous Sampling Boat For Pollution Source Survey.” Oceanalpha USV, Oceanalpha Co., 24 Oct. 2017.